

CHAPTER 8

EQUIPMENT MAINTENANCE

LEARNING OBJECTIVE: *Identify safe maintenance procedures and precautions that apply to water treatment equipment.*

Properly maintained equipment within a water treatment plant ensures smooth and efficient operation of water treatment. It is not possible to provide detailed instructions on the maintenance of each type of equipment in a water treatment plant. Therefore, this chapter covers general maintenance requirements and safety procedures on some of the more common types of water treatment. For specific and detailed maintenance instructions, refer to the manufacturer's manual for the type and make of equipment at your facility. In addition, this chapter provides information regarding different types of water storage facilities and the maintenance procedures applying to them.

CHLORINATORS

LEARNING OBJECTIVE: *Understand basic operation and preventive maintenance of chlorinators.*

Chlorinators are most often classified as direct feed or solution feed; however, they are also classified by the type of diaphragm used in controlling the chlorine feed. A description of each follows:

- Direct-feed machines operate without a water pressure supply, as they feed the chlorine gas directly to the flow to be treated
- Solution-feed machines dissolve the gas in a minor flow of water and inject the solution into the flow to be treated. They require a water pressure supply for operation.
- The water diaphragm machine is always a vacuum-type, solution-fed machine. The frictionless, punctureproof water diaphragm is an advantage,
- The mechanical diaphragm machine may be either a direct-feed or solution-feed pressure type, or the solution-feed vacuum type only.

DIRECT-FEED CHLORINATORS

Direct-feed chlorinators are used chiefly as emergency equipment and on small installations where it is not possible to obtain a water supply suitable for operating a solution-feed machine. They cannot be used where the pressure of the water being treated is more than 20 psi and are limited in the types of semiautomatic or automatic controls that may be used. Because of the chlorine always being under pressure as a gas, direct-feed machines leak gas easily to the atmosphere and cause corrosion on nearby equipment and structures.

Direct-feed chlorinators require the same maintenance of gas-piping and gas-feeding mechanisms as described for solution-type feeders. But direct-feed chlorinators do not require maintenance of equipment in contact with chlorine solutions, because there is no contact.

SOLUTION-FEED CHLORINATORS

Solution-feed chlorinators introduce chlorine gas into the water supply by means of a chlorine solution. This solution is usually formed by drawing chlorine gas into the jet stream of water at the low-pressure point of the injector mechanism of the chlorinator. Two general types are used in waterworks: the bubbling or pulsating reduced-pressure type and the vacuum type. Because they keep the chlorine under a partial vacuum, they cause fewer chlorine leaks than pressure gas chlorinators and direct diffusers.

CHLORINATION EQUIPMENT

Chlorination equipment to feed chlorine gas or hypochlorite solution is of three general types, depending on methods of control as follows:

- In the manually controlled type, equipment must be started and stopped manually, and rate of feed must be manually adjusted to rate of water flow.

- In the semiautomatic type, equipment starts and stops automatically as water flow starts and stops but must be manually adjusted to rate of water flow; this type is normally used with a water pump having a fairly uniform delivery.
- In the fully automatic type, rate of feed is automatically adjusted to rate of flow of water being treated by the differential pressure of a metering device. In all types, the ratio of feed to water treated, or dosage, is set manually.

Figure 8-1 shows a typical gas chlorination equipment piping diagram.

Hypochlorinators, or solution feeders, (fig. 8-2) introduce chlorine into the water supply in the form of hypochlorite solution. They are usually modified positive displacement piston or diaphragm mechanical pumps. However, hydraulic displacement hypochlorinators are used. Figure 8-3 shows a typical hypochlorination hookup.

Fully automatic types of hypochlorinators are actuated by pressure differentials produced by orifices, venturis, valves, meters, or similar devices. Care is necessary in their installation in mains to avoid restricted flows, which may limit the required amount of water for fighting a fire. Hypochlorinators are

sometimes used as standby equipment for gas chlorinators.

Portable hypochlorination equipment is also available which may be used for primary disinfection or during emergencies. They can also be used to feed chemicals for scale and corrosion control. A common type of portable Hypochlorinator used is the Proportioneers Chlor-O-Feeder. The Proportioneers Chlor-O-Feeder is a positive displacement diaphragm-type pump with an electric drive or a hydraulic operating head. The maximum capacity of the most popular type, the heavy-duty Midget Chlor-O-Feeder, is 95 gallons of solution in 24 hours. This unit can be operated in a semiautomatic or automatic application as follows:

- Semiautomatic control. The motor-driven type may be cross connected with a pump motor for semiautomatic control. The hydraulic type can be synchronized with pump operation by means of a solenoid valve.
- Fully automatic control. Motor-driven types are made fully automatic by the use of a secondary electrical control circuit actuated by a switch inserted in a disk or compound meter gearbox. This switch closes momentarily each time a definite volume of water passes through the meter, thus starting the feeder. A

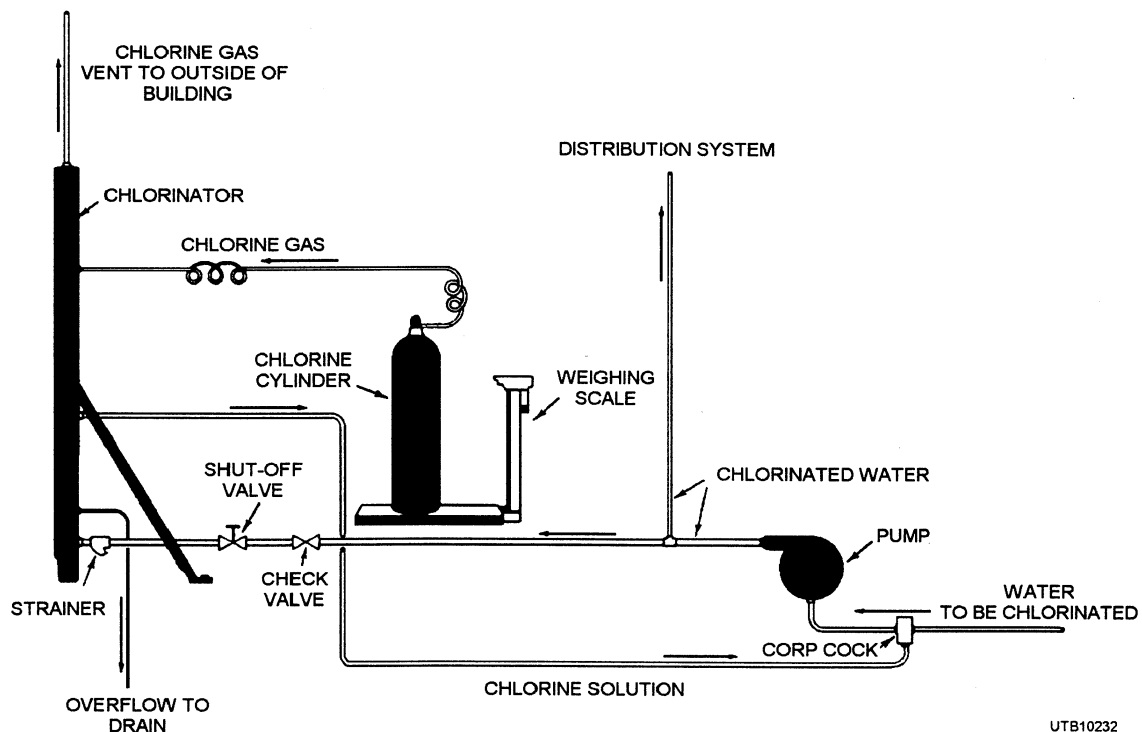


Figure 8-1.—Typical gas chlorination equipment piping diagram.

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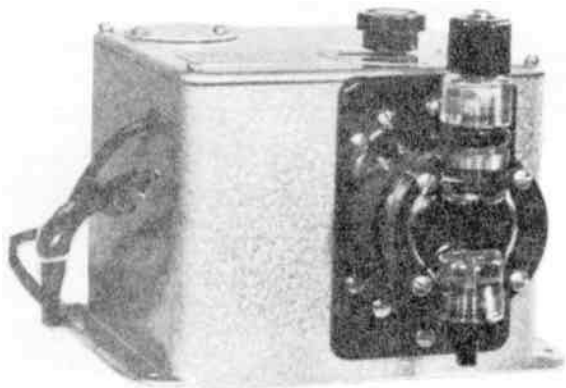


Figure 8-2.—Model S Hypochlorinator feeder (or pump).

timing element in the secondary circuit shuts off the feeder after a predetermined number of feeder strokes; the number of strokes is adjustable. In the hydraulic type (fig. 8-3) the meter actuates gears in a Treet-O-Control gearbox which, in turn, controls operating the

feeder. The dosage rate is controlled by water flow through the meter, thus automatically proportioning the treatment chemical. Opening and closing frequency of the valve thus determines frequency of operation of the Chlor-O-Feeder.

The Model S Hypochlorinator (fig. 8-2) is a positive displacement diaphragm pump with a manually adjustable feeding capacity of 3 to 60 gallons per day. A motor-driven eccentric cam reciprocates the diaphragm, injecting the solution into the main supply. The use of chemically resistant plastic and synthetic rubber in critical parts contributes to a long operating life.

It is not normal practice to locate hypochlorinators in the same room with other equipment, such as pumps, switchboard, meters, and the like. Because of the corrosiveness of the solutions, it is better practice to locate them in a separate room. In any event, adequate floor drains should be provided for carrying away wastewater, spillage, sludge, and washdown water. A curbing at least 6 inches in height should be

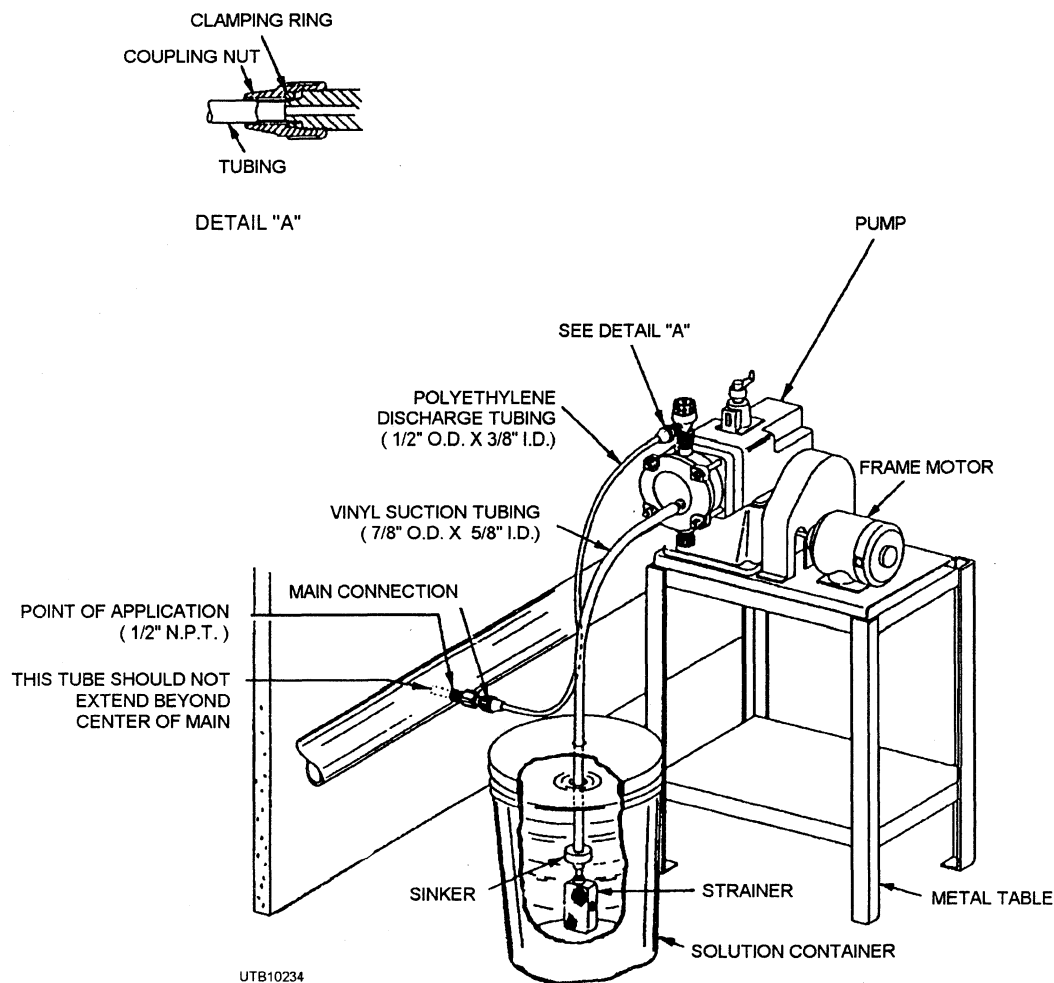


Figure 8-3.—Typical hypochlorination hookup.

provided around the entire area used for this purpose, whether in a separate room or in the same room with other equipment.

MAINTENANCE OPERATIONS

The maintenance operations described below apply to all gaseous chlorinators, regardless of type. Some preventive maintenance practices are fundamentally a part of normal equipment operations. Follow these precautions.

- When connecting chlorine valves or tubes to cylinders or equipment, use a new lead gasket each time, and use only one gasket in each connection.
- Guard against condensation on chlorine cylinder walls by maintaining proper ventilation around the equipment. Condensation may corrode scales or other equipment. An electric fan may be enough to keep the equipment dry.

CAUTION

Do not use direct heat to dry cylinder surfaces.

Chlorinators and all piping should be inspected daily for leaks. For chlorine leak detection, an opened bottle of aqua ammonia (or an aspirator-type bottle) should be used near all joints, valves, and piping. White fumes indicate chlorine leaks. Repair immediately, no matter how small, as they will increase in size and cause corrosion and damage which may become extensive. (Keep the ammonia bottle tightly closed when not in use.)

In addition to leak inspection, all parts and piping in contact with chlorine gas should be inspected daily to ensure that operations are satisfactory. This includes metering devices, valves, tubing, and so on, which should be disassembled and cleaned where necessary; the source of trouble should be determined; and faulty parts should be replaced at the first indication of weakening.

CAUTION

Tools should not be used on hard-rubber parts, except a strap wrench, if necessary; threaded, hard-rubber parts should be hand tightened.

Operation of the relief line should be checked daily; it should be open and contain no obstructions, such as wasp's nests.

The maintenance operation frequency and schedule of inspections for chlorination equipment are shown in appendix III, table A. In this and other tables used throughout the remainder of this chapter, note that the frequencies shown are suggested frequencies and may be changed by the local command, as individual installation conditions call for. The frequency code used in tables presented in our discussion is as follows:

D—daily

W—weekly

M—monthly

Q—quarterly

SA—semiannually

A—annually

V—variable, as conditions may indicate

- Q1. Chlorinators can be classified in two different ways. What are they?*
- Q2. In a semiautomatic type chlorinator, equipment starts and stops automatically with the water flow; however, the rate of waterflow is adjusted in what manner?*
- Q3. Hypochlorinators are sometimes used as standby equipment for what type of chlorinators?*
- Q4. How often should chlorinators and piping be checked for leaks?*

MAINTENANCE OF CHEMICAL FEEDERS

LEARNING OBJECTIVE: *Identify and understand basic maintenance guidelines for chemical feeders.*

DRY CHEMICAL FEEDERS

The instructions given apply to all types of volumetric and gravimetric dry feeders, including disk, oscillating, rotary gate, belt-type, screw, and loss-in-weight.

The basic maintenance operations that should be applied daily to all dry chemical feeders are as follows:

- Clean the feeder, the feeder mechanism, and the feeder surroundings. Use a vacuum cleaner or brush to remove spilled chemicals or chemical dust. Make certain that the orifice, knife edges, scrapers, shakers, and openings are free of chemical accumulations in volumetric feeders, and that both belt rolls and belt, in belt-gravimetric feeders, are free of chemical accumulations.

NOTE

When working with chemical dust, wear chemical goggles or a mask.

- Check the feeder for general performance. Note and investigate unusual noises.
- Observe the condition of electrical wiring, fuses, and connections
- Check for oil drips and general deterioration,
- Make necessary repairs to overcome deterioration and lack of good performance.
- Wipe all parts of the feeder and inspect for loose bolts, cracks, defective parts, and leaks. Make the necessary repairs to eliminate undesirable conditions.
- Check the solution tank for sediment or undissolved chemicals and remove accumulated material.
- When the dissolver is lined with asphalt, check the lining, which should not be skinned away from the steel. Follow the manufacturer's instructions to repair such linings.
- Quarterly, service moving parts and lubricate, following the manufacturer's instructions.

The maintenance operation frequency and schedule of inspections for dry chemical feeders are shown in appendix III, table B

SOLUTION FEEDERS

Maintenance procedures for pot-type solution feeders include the following:

- Daily operator inspection which includes observations of the amount of chemical feed to

determine whether flow through the post is effective.

- Monthly cleaning of the sediment trap and check of the valve.
- Cleaning of the chemical pot and orifice every 6 months.
- Annual overhaul that includes cleaning and painting the pot feeder and accessories.

With the decanter or swing-pipe feeder, the swing pipe should be checked monthly. The reducing gears, pawl, ratchet, and motor should be checked semiannually and overhauled annually, or as necessary. Overhauling includes cleaning, repairing, and painting all parts that require attention.

The maintenance operation frequency and schedules of inspection for liquid and solution chemical feeders are shown in appendix III, table C.

Q5. What personal safety equipment should you use when working with dry chemical feeders and chemical dust?

Q6. Moving parts and lubrication of a dry chemical feeder should be done at what intervals?

Q7. Overhauling a solution-feed chlorinator includes what three operations?

MAINTENANCE OF ION-EXCHANGE UNITS

LEARNING OBJECTIVE: *Identify and understand basic maintenance requirements for Ion-exchange units and equipment.*

An ion-exchange unit is shown in figure 8-4. Some of the maintenance procedures for this type of unit are given in the following sections.

SOFTENER UNIT

The softener unit itself consists of a steel shell, containing a supporting grid in the bottom, a layer of gravel, and a layer of ion-exchange resin. The shell is equipped with openings, valves, and fittings. Maintenance procedures for the unit are as follows:

- Annually, the exterior of the shell should be cleaned and brushed with a wire brush and then painted to protect it against corrosion.
- Quarterly, the fittings for the distribution of water and brine should be checked for possible obstructions, corrosion, and security fastness.

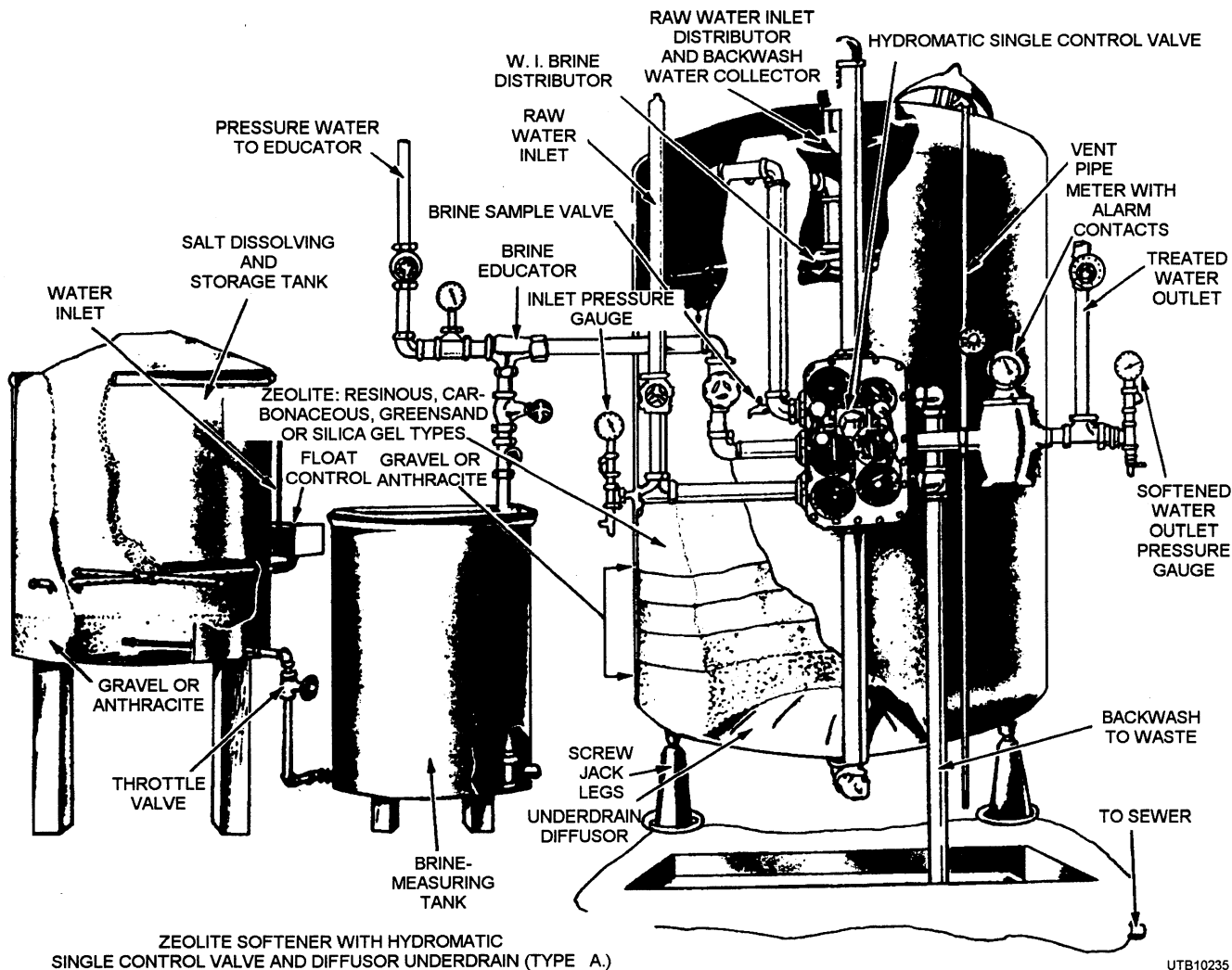


Figure 8-4.—Ion-exchange unit for water softening.

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- Every 6 months, each individual valve should be inspected and tested for leaks and repacked if necessary.
- Where multiport valves are used, they should be serviced and lubricated under the manufacturer's instructions. Lubricate this type of valve with grease as follows:
 1. Add grease by a pressure gun to each grease fitting while the valve is set in "service" or "wash" position.
 2. Turn valve one-half turn and add more grease.
 3. Give valve several full turns to spread the lubricant.

This lubrication does not require that the softener be removed from service, but when the water flow is stopped, no grease will get into the water.

Quarterly, flush ion-exchange beds with chlorinated water containing at least 2 ppm of chlorine. Do not use water with a hardness greater than 170 ppm, and be certain that the pH of the water is about neutral. Also, follow these directions.

1. Check the bed surface for dirt, fines, organic growths, and smoothness. Scrape excess foreign matter off and replace with new resin. When the surface is uneven, the gravel bed underneath is not distributing the wash water evenly. The remedy consists of removing the resin and gravel and replacing both in proper fashion.

2. Check the height of the ion-exchange bed surface; remove or add ion-exchange resin to maintain proper elevation. (A low elevation will allow excess fines and foreign matter to accumulate on the surface of the bed; a high elevation allows resin to be washed out during backwashing.) Extra ion-exchange resin may be

added through a 2- or 3-inch half-coupling (with brass plug), provided in the upper head of the shell or through the manhole cover plate.

3. Replace the ion-exchange bed with new resin whenever the inspection indicates the need, or when the exchange capacity has decreased and cannot be restored by cleaning and special procedures recommended by the manufacturer.

4. Quarterly, probe through the resin bed to determine the surface of the supporting gravel. The surface should be relatively even with a maximum difference of 4 inches between high and low spots. Any indication of shifting gravel bed, caking, or other difficulties, calls for repair efforts. Uneven gravel may be raked smooth, through the open manhole, during backwashing operations.

When gravel needs to be removed, it may be cheaper to install new gravel than to remove, wash, and regrade old gravel. New gravel should be lime-free (do not use ordinary river gravel). When old gravel is reused, screen out all resin particles. Spraying with water is the best method of removing the resin from the gravel on the screen.

Replace or add new gravel in four layers. Fill the shell with water to the depth desired, then add the coarsest grade first; level the gravel layer to fill low spots; next, raise the water level to the next depth required and add the next smaller grade. Repeat the process; then, add the resin to the desired depth and classify by backwashing the bed.

Annually, or as necessary, the condition of underdrains may be learned from the pressure drop across the underdrain system with a full backwash flow being discharged from the manhole. A greater pressure drop than existed at the time of installation shows plugging underdrains; a lesser pressure drop reveals displaced or corroded nozzles. Underdrains should be inspected, removed, cleaned, painted (where necessary), and replaced every 3 years

Manifold-type underdrains should be inspected when gravel is removed. Remove several laterals at random and check for clogging. Where clogging is evident, remove all laterals and clean mechanically, or treat with inhibited muriatic acid.

Plate-type underdrains should be removed, inspected, painted, and replaced every 3 years; make

certain that the clearance space between the plate and lower head is the same at all points.

REGENERATION EQUIPMENT

For regeneration equipment, the maintenance procedures are as follows:

1. The salt storage tank should be cleaned at varying periods, depending on the amount of insolubles in the salt, tank size, and the salt usage. Rock salt contains more insolubles than evaporated salt. (The greater the salt usage, the more frequent the cleaning required.)

2. The brine-measuring tank should be cleaned every 6 months, and both exterior and interior surfaces painted.

3. At annual intervals, the brine ejector should be cleaned, disassembled, and checked for erosion or corrosion; any clogging of piping should be removed before the ejector is reassembled and replaced.

The maintenance operation frequency and schedule of inspections for ion-exchange softening units are shown in appendix III, table D.

Q8. The exterior shell of a water softener unit should be cleaned a minimum of what frequency?

Q9. Does a water softener need to be removed from service when multiport valves are lubricated?

Q10. When flushing ion-exchange beds with chlorinated water, the water used should be of what pH?

Q11. Of the salts used in softening water, which contains less insolubles, rocksalt, or evaporated salt?

MAINTENANCE OF CLARIFICATION EQUIPMENT

LEARNING OBJECTIVE: *Identify and understand basic maintenance procedures for clarification equipment.*

Maintenance procedures for clarification equipment are discussed below. The equipment includes mixers, flocculator basins, and sedimentation basins.

MIXERS

Mixing basins, whether baffled or mechanically stirred (rapid or flash), require attention and cleaning semiannually. The maintenance requirements are as follows:

1. After draining, wash down the walls with a hose and flush the sediment to the drain. Repair spalled spots on walls or bottom as necessary.
2. Check the valves or sluice gates for corrosion and ease of operation; clean and lubricate; paint valves as necessary.

FLOCCULATOR BASINS

The following maintenance procedures apply to flocculator basins:

- Monthly, during operation, check paddle rotation to assure that all flocculators are operating. Lower a light pole (bamboo fishing rod) into the water until the paddles strike the pole, revealing paddle operation. Broken shafts or chains may cause the paddles to become inoperative.
- Semiannually, drain and clean the basin, walls, and floor; inspect the flocculator mechanism, drive, bearings, gears, and other mechanical parts; clean and lubricate. Especially check underwater bearings for silt penetration. Replace scored bearings. Paint mechanism parts where necessary.

SEDIMENTATION BASINS

All types of settling basins require the same basic maintenance, such as lubricating, cleaning, flushing, and painting. Basins, which have mechanical devices, should be maintained under the manufacturer's instructions.

Revolving-Sludge Collector Basins

Specific maintenance procedures for revolving-sludge collector basins should agree with the manufacturer's instructions. The procedures described here are the minimum.

Regular lubrication is required where the basin is in continuous operation. Intermittent operation affects the lubrication schedule, making it possible to increase the interval between lubrication periods. When operating periods are intermittent and infrequent, the mechanism should be operated briefly between

operating periods and lubricated. Devices subject to wide seasonal temperature changes must have seasonal changes in lubricant grades, especially where summer grade oils thicken below freezing and reduce the flow capability. Daily or weekly lubrication of operating units is a part of operator inspection. The choice of lubricant and its frequency of application are established by the manufacturer or by local command.

Other devices found in the equipment require attention on a regular basis. Some examples of these devices and required care are as follows:

1. The speed reducer should be inspected weekly to ensure that the oil is at the proper level, is free of water and grit, and has the right body. When a reducer runs hot during its operation, the oil level may be too high or too low. (Where the reducer is out of service for a long time, make certain it is filled above the level of the seals to prevent the seals from drying out. Be sure it is tagged to reflect this condition. The reducer must be drained to proper level before being placed back in service.) Replace oil whenever necessary.
2. The drive head should be lubricated daily, but not too much.
3. The worm gear oil level should be checked at least weekly, and the water drained from the housing monthly.
4. The turntable bearings should be lubricated monthly and the oil changed twice yearly.
5. Lubrication procedures for chains depend on the design of the chain and chain guard. Inspect monthly and add oil as necessary; drain off the accumulated oil as necessary; and change the oil twice yearly.
6. Ball bearings and thrust bearings are lubricated annually. They should be inspected monthly for wear and proper lubrication.
7. Center bearings, shaft bearings, bushings, and so on, are lubricated under the manufacturer's instructions.

Tank equipment requires annual inspection. The steps for this inspection are as follow:

1. Check bolts and tighten nuts to maintain original alignments and adjustments.

2. Check for excessive wear of moving parts, including gears.

3. Flush and back blow the sludge withdrawal line by using high-pressure water or compressed air.

NOTE

Do not allow the waterline to be cross connected to the drinking water supply system.

4. Check the plows or rakes and straighten them if necessary.

5. Check the motor condition, couplings, and service shear pins.

6. Clean equipment and paint as necessary.

When the equipment has an overload alarm, check it for operation. If the alarm sounds at any time, shut off the equipment, locate the source of trouble, and correct it. Under no condition should the alarm switch be nullified to provide continuous operation. If the overload is caused by a sludge buildup leading to cutout of the starter switch or pin shearing, the tank must then be drained and the sludge flushed out.

Conveyor-Type Collector Basins

As with the revolving-sludge collectors, specific maintenance procedures in conveyor-type collector basins are in the manufacturer's instructions. Maintenance procedures on the tanks and structures are the same for this type of sedimentation basin as they are for the circular-type basin. Generally, the maintenance procedures for gears, chains, sprockets, reducers, and so on, are also the same as those for circular-type basins.

Cathodic Protection

Where stubborn water problems exist in water supplies, the sedimentation tank equipment may be protected by cathodic protection. Cathodic protection is a method of protecting metal surfaces from corrosion through the use of a direct-current voltage. The voltage is applied so that the current tends to flow from the direct-current source through the soil or water to the metal surface to be protected. This flow of

current applies electrical energy that reverses the natural process of corrosion.

There are two well-known methods of cathodic protection: the impressed current system and the galvanic anode system. The impressed current system requires graphite rods and an external power source to establish enough voltage. The galvanic anode system, which requires no external power supply, uses metallic anodes, such as magnesium, zinc, or aluminum.

Cathodic protection systems may be maintained by activity personnel or by service contract. The field engineering officer will provide guidance in developing maintenance procedures or in contracting for such services.

IMPRESSED CURRENT SYSTEM.—Make inspections and necessary maintenance repairs at monthly intervals. The steps for the inspection include the following:

1. Check exterior of enclosure for rust, corrosion, or mechanical damage; check hinges and locks for inadequate lubrication, rust, or other deficiencies; check wiring and fastenings and rectifier for broken or damaged insulation, and for rust or corrosion on conduit; and, check exposed wires and cables and all electrical connections for insecurity, frayed or broken insulation, and other deficiencies.

2. Check interior of enclosure for rust, moisture condensation, loose wiring, and signs of excessive heating. (Do not put hand tools inside the enclosure.)

3. Check anode suspensions for rust, corrosion, bent or broken suspension members, frayed or broken suspension lines or cables, loose bolts, loose cable connections, and frayed or broken wiring.

4. Whenever necessary, replace or repair any item which will not pass inspection for continued service, and paint switch cans and exposed rectifier housing and other electrical gear as necessary.

GALVANIC ANODE SYSTEM.—The only maintenance required for a galvanic anode system or a sacrificial anode system is monthly inspection and potential tests to determine when replacement of anodes is necessary and to ensure continuity of the electric circuit. The procedures that apply are as follows:

1. When an abnormal decrease in current output (or potential of the protected structure) occurs, the

anodes should be inspected for excessive disintegration.

2. Check terminals and jumpers of test leads for rust, corrosion, broken or frayed wires, loose connections, and similar deficiencies. Tighten all connections.

3. Check the bushing supporting the anode for rust and corrosion. Where resistors are installed in the circuit, examine these units for corrosion, broken and frayed wires, and loose connections. Tighten all connections.

4. Check the anode suspensions for rust, corrosion, bent or broken suspension members, frayed or broken suspensions lines or cables, loose bolts, loose cable connections, and frayed or broken wiring. Install new anodes when necessary.

WARNING

Do NOT bridge insulated couplings or break electrical connections without engineering advice.

The maintenance operation frequency and schedule of inspections for clarification equipment are shown in appendix III, table E.

Q12. Collector basins should never be cross connected with what type of water system?

Q13. What are the two methods of cathodic protection for sedimentation basins?

Q14. What cathodic method requires no external power supply?

MAINTENANCE OF FILTRATION EQUIPMENT

LEARNING OBJECTIVE: *Identify and understand basic maintenance for filtration equipment.*

Maintenance procedures on both gravity and pressure filters are essentially the same, differing only in detail. Some of the maintenance operations for diatomite filters are similar to those for sand filters; others are not.

GRAVITY FILTERS

Regardless of the type of filter medium used (sand or anthrafil), the material filtered out of the water must be removed from the filter at regular intervals. (See fig. 8-5.)

Filter Media

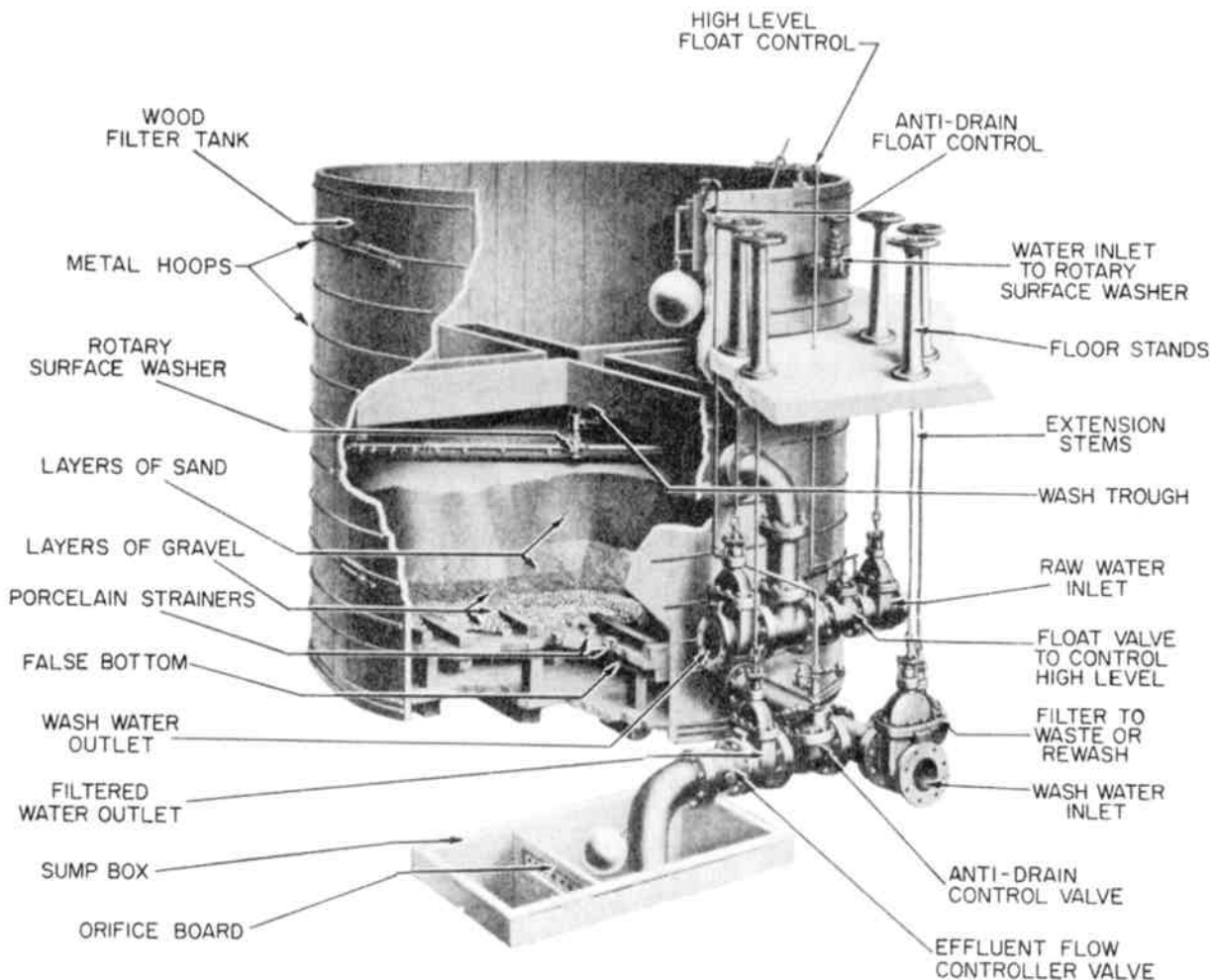
During daily backwashing, as an operating procedure, the operator should observe any conditions which may indicate a need for more complete inspection. The MINIMUM procedures are as follows:

- At monthly intervals, drain the filter to the surface of the filter medium; inspect the surface for unevenness, sinkholes, cracks, algae, mud balls, or slime.
- When depressions or craters on the surface are of appreciable size, dig out the sand and gravel, and locate and repair any break in the underdrain system.

When a filter bed is not backwashed correctly, sand grains and foreign matter begin to stick together. Over a period of time, large clumps, called mud balls, are formed. They lower the efficiency of the filter bed and must be removed. Surface washing usually breaks down these formations, and they can then be removed by backwashing. When the plant does not have surface wash equipment, mud balls may be removed by the steps of the procedure as follows:

1. Wash the filter bed completely clean at 2- to 3-week intervals by using about twice the usual amount of backwash to make sure the bed is cleaned thoroughly.

- When the wash water is clear, reduce the rate until the bed is expanded about 20 to 25 percent to expose mud balls on the sand surface.
- Remove the mud balls manually with a 10-mesh screen attached to a long handle.
- When sand shows evidence of algae, prechlorinate ahead of filters. Where severe algae growths exist on sand or walls, remove the filter from service and treat the filter with a strong hypochlorite solution. Add enough hypochlorite to produce 2 to 4 ppm of free residual chlorine in a volume of water 6 inches deep above the filter surface. Draw down the filter until the water level is just above the bed surface. Allow it to stand for 6 to 8 hours, then backwash the surface, and follow this by a complete backwashing. Repeat if necessary.



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Figure 8-5.—Cutaway view of gravity sand filter with rotary surface wash.

2. Quarterly, during a backwashing period, probe the filter for hard spots and uneven gravel. Examine the sand below the surface by digging to gravel with the water drawn down to the gravel level. When clogged areas appear because of cementation of sand grains with mud balls or because of carbonate deposits or if the sand (or anthrafil) grains have increased in size because of incrustation (e.g., in softening plants or where lime and ferrous sulfate are used for coagulation), clean the sand by treating the idle filter with an inhibited muriatic acid or sulfurous acid. The advice of the public works officer should be obtained if the operator is unfamiliar with the use of these chemicals.

- Add the inhibited muriatic acid at the surface and allow it to pass downward through the bed and out the filter drain or “rewash” the line or add it to an empty filter through a small tap on the bed side of the ash-water line.

- Use sulfurous acid as follows: Allow the sulfur dioxide gas from a cylinder to discharge into the filter wash waterline while slowly filling the filter bed with wash water. Use one 150-pound cylinder to 6,000 gallons of water to produce a 0.3-percent solution. Allow it to stand for 6 hours.
- Semiannually, ascertain any change in the rate of wash water rise, as determined during operating procedures, and check sand expansion. Inspect the sand and, if you do not see the condition of the medium, locate the elevation of the top of the bed to determine if the bed has “grown” in depth. Also, remove a sand sample and analyze it as follows:
- Make a sampling tube 12 inches square by 36 inches deep. Force a tube to the gravel level and

drain the bed. Remove the sand from within the tube.

- Collect several such samples from well-scattered locations on the filter bed, mixing until about 2 pounds remain. Dry this sample; mix, quarter, and reduce to a usable sample size.
- Determine loss of weight of a 10-gram sample during acid treatment. Treat the sample with 10 percent hypochloric acid in a Pyrex evaporating dish in a water bath for 24 hours. Replace acid loss during treatment period. Wash, dry, and weigh the sand. Determine the weight loss and compare it to the previous analysis.
- From the remainder of the sand sample, remove 100 grams and run a sieve test. Compare the results to previous tests.

When either inspection, weight loss or sieve analysis shows growth of sand grains to a point where filtration efficiency is impaired, treat the sand as follows:

- Add inhibited muriatic acid at the surface and allow it to pass downward through the bed and out the filter drain, or “rewash” the line; or add it to an empty filter through a small tap on the bed side of the wash waterline.
- Adjust the water treatment process as necessary. If treatment is not effective, replace the filter medium.

Gravel Inspections

Gravel inspection procedures include the following:

1. At monthly intervals, check the gravel bed surface for unevenness, using a garden rake or a pole as a probe during backwashing. When ridges or sinkholes are shown, the filter may need overhauling.
2. Every 6 months, remove sand from an area about 3 square feet, taking care not to distribute the gravel. Examine the gravel by hand to determine if the gravel is cemented with incrustation or mud balls, or if it is not layered properly.
3. When any undesirable conditions exist to a marked degree, the sand should be removed and the filter gravel relaid. When unevenness or layer mixing is caused by a faulty underdrain system, repair it; when it is caused by faulty backwashing, correct the backwashing procedure.

Filter Underdrain Systems

Annually, or as observations indicate the need, the filter bottom should be inspected. Sand boiling during backwashing or sand craters on the surface indicate trouble in the underdrain system, as does marked unevenness of the gravel layers. Inspection and treatment procedures are as follows:

1. To inspect the bottom, remove the sand over an area of about 10 feet square. Select an area where sand boils or other indications of trouble have been noticed. Place planking over the gravel to stand on, and remove the gravel from areas about 2 feet square. Check the underdrains for deterioration. When the underdrains need repair, remove all sand and gravel, make repairs to the underdrain, and replace the gravel and sand in proper layers.

2. Where the underdrains are porous plate and are clogged with alum floc penetration, flood the underdrain system with a 2 percent sodium hydroxide solution for 12 to 16 hours.

Wash Water Troughs

At quarterly intervals, the level and elevation of troughs should be checked. Water should be drawn below the trough lip, the wash water valve cracked, and any low points observed where water spills over the lip, before the lip is covered completely.

The troughs should be adjusted as necessary to produce an even flow throughout their lengths on both sides.

At 6 month intervals, metal troughs should be inspected for corrosion. When corrosion exists, the troughs should be allowed to dry, and then cleaned by wire brush and painted with a protective paint or coating.

Operating Tables

Operating controls for filter valves may be mounted on a console, panel, or table. The controls actuate the filter valves which may be powered either by hydraulic or pneumatic means. The controls may be connected to the valve mechanism either mechanically, electrically, hydraulically, or pneumatically.

Maintenance operations that should be performed weekly are as follows:

1. Clean the table, the console, or the panel inside and out, using soap and water if necessary.
2. When mechanically operated, check the tension on the cables or the chains, used for connection to the valve operator or for connection to the valve-position indicators.
3. When hydraulically operated, inspect for leaks and stop any leakage; when pneumatically operated, check tubing for possible leakage.

Maintenance operations that should be performed monthly are as follows:

1. Transfer valves (four-way) and handles should be adjusted monthly to make certain that all filter valves open at the same rate. Packing glands should be tightened or new packing added if needed.
2. Transfer valves should be lubricated monthly with grease. They should not be overlubricated; one-half turn of the grease screw (cup) should be enough.
3. The valve-position indicator should be inspected monthly and adjusted to ensure that it reads correctly in all positions.

Maintenance operations that should be performed annually are as follows:

1. The four-way transfer valves in the table should be disassembled annually and any worn parts, seats, or washers should be cleaned or replaced with new ones.
2. The inside of the table, console, or panel should be painted annually to protect against corrosion.

Rate Controllers

Rate-of-flow controllers (fig. 8-5) may be either direct acting or indirect acting.

Maintenance procedures for a direct acting rate-of-flow controller is as follows:

1. Weekly, clean the exterior, check for leakage through the diaphragm pot, and lubricate or tighten packing to stop any existing leakage. Also, ensure that both the diaphragm and the control gate move freely

between zero differential and the open and closed positions.

2. At intervals of 1 or more years, remove and disassemble the diaphragm pot, including the rubber diaphragm. When the water does not cause tubercles, this operation may not have to be done more than once every 3 to 5 years. The term *tubercles* refers to small, more or less hemispherical lumps on the walls of the pipe, which increase the friction loss and, by reducing the velocity, also reduce the capacity of the pipe. Tubercles result from tuberculation, a condition which develops on the interior of ferrous pipelines, caused by corrosive materials present in the water passing through the pipe.

3. Every 3 years, disassemble and service the controller gate and mechanism. Inspect the venturi throat. Paint or apply protective coating as necessary.

With indirect-acting controllers, the following maintenance procedures apply:

1. At weekly intervals, clean the outside of the controller; adjust the packing; lubricate or tighten the fittings as necessary to stop any leakage from the hydraulic cylinder, the controller valve, the piping, or the pilot valve. Make sure that the knife edges seat correctly and are free of paint or other foreign matter. Also, be sure that the piston has free vertical travel and does not bind. Replace packing if necessary.

2. Annually, disassemble, clean, and lubricate the pilot valve. Remove foreign matter from the piston with a cloth. Never use an abrasive to clean the piston. Make certain that no foreign matter enters the pilot valve during the cleaning operation. Check for leaks or cracks in the diaphragm.

3. Every third year, disassemble and service the controller gate and mechanism; inspect the venturi throat and apply protective coatings where necessary. Check the hydraulic cylinders, and maintain them under the manufacturer's instructions.

Gauges

Various types of indicating and recording instruments may be mounted on the operating table or control panel. Here, we will take up one device, the diaphragm-pendulum unit loss-of-head gauge. Where the actuating mechanism is of this type, the general

maintenance procedures given here apply. For a more detailed discussion of these procedures, consult the manufacturer's instructions.

The following maintenance operations are required on a monthly basis:

1. Purge the diaphragm cases of air, and check the cable to be sure that it leaves the segment at a tangent to the lower end when a zero reading exists on the unit.
2. Remove dirt from the knife edges; when necessary, tighten the cam hubs on their shafts.
3. Drain mud from the mud leg. In doing this, flush the mud out of the water pipeline running from above the sand to the loss-of-head gauge. Drain the mud leg until the water runs free of sediment.

Annually, inspect the diaphragms for leakage, and replace when necessary.

NOTE

Diaphragms in stock should be stored underwater.

Also, disassemble the unit to clean and lubricate it when necessary. Check the working parts and the cables. (They should be free of knots, splices, or fraying.) Repack the stuffing box when it is leaking. Make certain that the knife edges rest solely on their edges where the pendulum is hung vertically, and be sure that all cable ends are knotted tightly.

PRESSURE FILTERS

Except where the filter medium is housed in an enclosed pressure shell, pressure filters (fig. 8-6) are constructed like gravity filters with respect to the underdrain system, gravel, and the filter medium (sand or anthrafilt). Pressure filters need the same care and attention as gravity filters. Since their backwashing operations cannot be observed, the filter must be opened regularly and inspected carefully. The recommended maintenance procedures are as follows:

- Weekly, inspect piping and valves for leaks. Lubricate and repack valves if necessary.
- Quarterly, open the pressure shell and inspect the filter bed surface. The inspection procedures are as follows:

1. Use a garden rake during backwashing while the manhole is open to test for mud balls in the lower part of the filter bed and for evenness of the gravel layer surface.

2. Determine when the sand bed level has changed since the last inspection by comparing the bed surface elevation with some reference point.

3. When the filter does not have a surface wash system and shows evidence of mud balls, backwash it at the highest rate possible while jetting the surface with a stream of water from a high-pressure hose nozzle.

- Annual maintenance requirements are as follows:

1. Open the filter, remove the sand from an area large enough to permit the inspection of the gravel. When the sand or gravel distribution indicates nonuniform distribution of backwash water, the filter media and gravel may need to be removed, and the underdrain system checked.

2. Clean and paint the exterior of the shell.

- Every 3 years (or more often if necessary), the filter medium and gravel should be removed and the underdrain system checked for the distribution of wash water, and repaired if necessary. Clean the under-drain system, and paint it or apply a protective coating to all parts subject to corrosion, including the inside shell. Replace the gravel and the filter medium.

DIATOMITE FILTERS

Most diatomite filter installations in potable water supply plants are of the pressure type, although there are vacuum-type filters that can be used in certain installations. In general, the maintenance procedures for cleaning the filter element are the same for both types. The following procedures apply:

At monthly intervals, or as often as operating conditions show the need, check the filter elements. Cleaning is needed if the precoat has apparent bare spots on the elements. Causes of element clogging are iron oxide, manganese dioxide deposits, and algae growths.

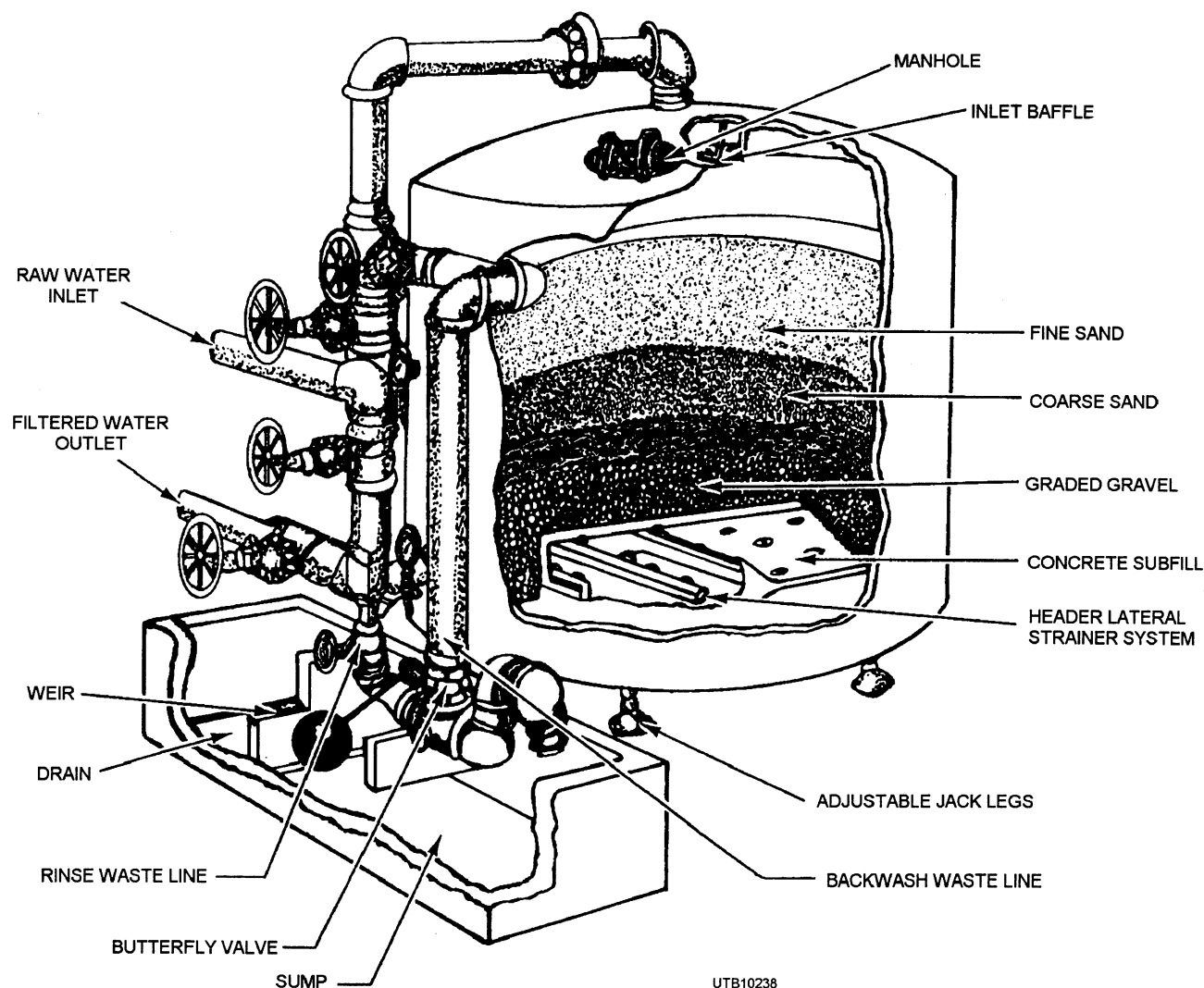


Figure 8-6.—Pressure-type rapid sand filter.

For iron oxide removal, treat the elements with a 0.5-percent solution of oxalic acid. Information is available from manufacturers on the amount of oxalic acid to use on different size units. The procedures used to remove iron oxide are as follows:

1. Start with an empty filter after a regular washing.
2. Close the drain valve and the main outlet valve; open the recirculation valve.
3. Fill the tank to a level covering the top of the elements.
4. Add the proper quantity of oxalic acid, and recirculate for 1 hour.
5. Drain and hose down the elements and the tank interior.
6. Close the drain valve; refill, circulate a few minutes, and then drain again. When the

cleaning is not completely effective, repeat the procedure.

The procedure for manganese dioxide removal is the same as for the removal of iron oxide, except that anhydrous sodium bisulfite must be added to the solution. (See the manufacturer's instructions for the correct amount.)

To remove algae growths, add a 12 ½ percent hypochlorite solution to the tank volume after filling the tank to the proper level. (See the manufacturer's instructions for the proper amounts to use for different size units.)

Semiannually, check the piping and valves and other equipment, including the body feed equipment. Make whatever adjustments the manufacturer's instruction says.

Clean and paint all exterior surfaces annually if necessary.

The maintenance operation frequency and schedule of inspections for filtration equipment are shown in appendix III, table F.

- Q15. Backwashing should be performed on gravity filters at what intervals?*
- Q16. When severe algae growth exists on filter sand or walls, what corrective action should be taken?*
- Q17. Sodium hydroxide is used in filter underdrain systems of porous plate to correct what condition?*
- Q18. What are the two types of flow rate controllers?*
- Q19. What is the major difference between a pressure filter system and a gravity filter?*
- Q20. To remove iron oxide in a diatomite filter, a solution of what chemical and at what percent should you use?*

MAINTENANCE OF AERATION EQUIPMENT

LEARNING OBJECTIVE: *Identify and understand basic maintenance for aeration equipment.*

Proper maintenance of aerators is another important area in water treatment activities.

WATERFALL AERATORS

The recommended maintenance procedures for waterfall-type aerators (cascade or step, and tray or splash pan) is as follows:

- Weekly, inspect the aerator surfaces for algae or other growths, precipitated iron oxide, and for nonuniformity of water distribution and staining. Clean when necessary. Treat with copper sulfate or hypochlorite solution to destroy growths.
- Every 6 months, clean and repair tray aerators, removing the trays as necessary. Inspect the coke tray aerators for biological growths and coke deterioration. Replace the coke if the cleaning is not effective. Repair the screen and enclosures if necessary.
- Annually, repair or replace the surfaces on cascade or step aerators.

INJECTION OR DIFFUSER AERATORS

Injection or diffuser aerators may be either porous medium design or injection nozzles.

Porous Ceramic Diffusers

The maintenance procedures for porous ceramic diffusers-plate or tube-is as follows:

1. Upon evidence of the nonuniform distribution of air or clogging that impairs operation, dewater the tank; inspect and clean diffusers if necessary.
2. Every 6 months, drain the aeration tank and inspect the diffusers for joint leaks, broken diffusers, and clogging. Porous ceramic diffusers may suffer clogging of either the waterside or the air side (underside).
 - For waterside (porous plate diffusers), use oxidizing acids to clean organic growths from the plate surface.

NOTE: Chlorine gas introduced into the air line at intervals between inspections will help hold down organic growths.

- Removable plates should be soaked in 50 percent nitric acid. Plates grouted in place cannot be treated with nitric acid; use chromic acid (made by adding 1 gram of sodium dichromate to 50 ml of sulfuric acid). Pour approximately 2 fluid ounces on each plate 2 days in a row.

WARNING

Acids must be handled carefully. DO NOT pour water into sulfuric or chromic acid, as it will explode or splatter. Such acid will cause severe burns to the skin and clothes. ALWAYS pour acid SLOWLY into the water, while stirring continuously. Acid treatment should only be done only upon the approval of the Public Works Officer under supervision of a chemist or other qualified personnel.

- Air side (porous plate diffusers). When clogging is caused by iron oxide particles from pipes, treat this condition with a

30-percent solution of hydrochloric acid. If clogging is by soot, oil, or dust from improperly filtered air, remove the diffusers and burn off the extraneous material in a furnace.

- Porous ceramic tubes. Tubes may be removed and cleaned by soaking in acids or by burning (as described for porous plate diffusers).

Porous Saran-Wound Tube Diffusers

These diffusers should be inspected and cleaned semiannually as necessary. This material cannot be subjected to strong acids or heat. It must be scrubbed with a brush and soap or detergent.

Injection Nozzles

Injection nozzles should be inspected and cleaned semiannually as necessary. Diffuser nozzles on header lines may become clogged from deposits inside from iron oxide particles, or on the outside from organic growths. Clogging from the inside may require removal of the individual nozzles for cleaning. Chlorine gas injection into the air line header between inspections will hold down organic growths. At inspection periods, if growths are present, scrub them off with a brush and detergent solution to which hypochloride has been added.

SPRAY NOZZLE AERATORS

The maintenance procedures for spray nozzle aerators is as follows:

- At weekly intervals, check the nozzles for clogging, and clean when necessary. Remove the nozzles only when necessary. Check for adequate spread.
- Quarterly, check air line manifolds, remove caps and clean out sediment; check for joint leaks. Check pipe supports, replace or repair, and paint as necessary.
- When spray fences exist, repair and paint them annually.

BLOWERS AND ACCESSORY EQUIPMENT

The procedures for injection aeration is as follows:

- Daily, lubricate the blower or compressor under the manufacturer's instructions. Check output pressures.

- Weekly, inspect the air filters; clean, repair, or replace them as necessary.
- Annually, open the blower or compressor and inspect for internal erosion or deterioration; repair as necessary. Paint exterior surfaces.

Maintenance operation frequencies and the schedule of inspections for aeration equipment are shown in appendix III, table G.

Q21. Waterfall-type of aerators use what type of action to create water?

Q22. What reaction will occur when water is poured into sulfuric or chromic acid?

Q23. Chlorine gas injection into the air line header of injection nozzles will reduce what condition?

SAFETY AND EMERGENCIES

LEARNING OBJECTIVE: *Recognize and understand basic safety procedures for use, handling, and storage of water treatment chemicals. Understand first aid for chlorine gas.*

The operation of water treatment plants is a hazardous occupation, with dangers from noxious gases and vapors, physical injury, and infections. Work should be carried on only under the supervision of an experienced workman or operator who is trained in first aid and is familiar with the hazards of the work.

CHLORINATION

Specific precautions in handling ammonia, chlorine, and chlorine-yielding compounds were shown in an earlier chapter on water treatment plants. A number of chlorination safety precautions are given below.

- Provide self-generating oxygen-breathing apparatus or self-contained oxygen-breathing apparatus designed to cope with chlorine.
- Maintain only the supply of chlorine in any chlorinator room that will do for normal daily demands. Store the main supply in a detached noncombustible building or in a fireproof room which is vented only to the outside and which is separated from the main part of the building. Keep the chlorinator and chlorine storage buildings or rooms locked to prevent the entrance of unauthorized personnel and restrict these areas from any other use.

- Allow only reliable and trained personnel to handle chlorine.
- Handle containers carefully to avoid dropping or bumping them.
- Avoid hoisting containers as much as possible; when hoisting is necessary, use safe lifting clamps.
- Store cylinders in a cool place, away from dampness, steam lines and fire, and in an upright position secured from tilting and falling.
- Keep protective valve caps on containers when not in use; never tamper with safety devices on containers.
- Never connect a full cylinder to a manifold with another cylinder, unless temperatures of both are nearly the same.
- When not withdrawing chlorine or when cylinders are empty, keep the valves closed.
- Disconnect the valves as soon as the containers are empty, and check for chlorine leaks at the valve outlets. Test for leaks by passing an opened bottle of strong ammonia solution around the valve. White fumes of ammonium chloride will appear if there is any leakage. Leaks around fittings, connections, and lines can be detected in the same way. Do not apply ammonia solution to plated metal parts because it will remove the plating.
- When chlorine is noticed, workers should avoid panic, refrain from coughing, keep the mouth closed, avoid deep breathing, keep the head high, and get out of the affected area. Only qualified personnel with suitable respiratory equipment will be assigned to investigate and correct the cause of chlorine leaks. When chlorine is being discharged, close the container valve immediately. When chlorine is escaping in liquid form, turn the containers so the chlorine escapes as gas, which will reduce leakage. Do not apply water to the leak; this dangerous practice causes corrosion that may increase the leakage. Electronic chlorine gas detectors are widely used in water plants today.
- The handling of a persistent chlorine leak in a plant is best left to the chlorine supplier.
- Never apply a flame, blowtorch, or other direct heat to chlorine containers; discharge them in a room with a temperature of about 70°F.

- Never ship a defective or leaky cylinder unless it is completely empty. Paint Defective plainly on all such cylinders.
- Follow all regulations on shipping, storing, and using compressed gas cylinders.
- Provide proper means of exit from areas where chlorine is stored or used.
- Never use a chlorine cylinder except to hold chlorine gas.

First Aid for Chlorine Poisoning

Should any of the plant personnel become affected by chlorine gas or be overcome by its action, the steps for providing the victim first aid are as follows:

1. Remove the affected person at once to open air and away from gas fumes.
2. Call a physician.
3. Place the patient flat on the back with the head slightly elevated. Keep the patient warm and calm.
4. If conscious, give the patient one-half teaspoonful of essence of peppermint or a moderate stimulant. Do NOT give milk, as milk or cream will usually curdle in the stomach and cause vomiting which adds to the discomfort of the patient.
5. If able, the person affected should try not to cough.
6. If the patient is unconscious and not breathing, apply artificial respiration.

Emergency Treatment

For almost any chemical spillage on personnel, quick, thorough, and continued flooding of the affected body area with water is the best general first-aid measure. Call a medical officer for chemical burns, and ALWAYS for eyes affected by the accident.

HANDLING LIME

Operators must be particularly attentive to the commonsense rules of good housekeeping in handling lime. This chemical should be carefully stored in a dry area.

Other safety precautions for the handling of lime are as follows:

- An efficient dust-collecting system should be used whenever dust is present at handling points.
- A dry-pickup vacuum cleaner should be used for removing dust around unloading equipment and chemical feeders.
- Protective clothing should always be worn for personal safety in case bags break or the dust-collection system fails. The proper dress is heavy-denim clothing with long sleeves, heavy gloves, bandanas, and trousers tied around the shoe tops. Chemical goggles and suitable dust masks should be worn. Any exposed skin areas should be covered with protective creams.

WARNING

Avoid accidental contact of quicklime or slaked lime with water as it generates excessive heat. Serious skin burns and eye damage can be caused by contact with hot lime solution. ALWAYS WEAR CHEMICAL GOGGLES OR FACE SHIELDS WHEN LIME FEEDING EQUIPMENT IS BEING OPERATED.

HANDLING AND STORING CHEMICALS

In handling and storing chemicals, observe all safety precautions.

- General.

1. Wear appropriate-type chemical cartridge dust masks when bags of chemicals or bulk material are unloaded or otherwise handled. When the chemical is particularly irritating or dust is excessive, wear chemical goggles.
2. In handling toxic solutions, a face shield, boots, gloves, and a rubber apron afford required protection from splashes or sprays.
3. Store chemicals in a clean, dry place. Store bagged or mixed chemicals in single or double rows with access aisles around each stack for frequent fire inspection. This type of storage makes it easier to remove burning chemicals.

4. Store chemicals in separate areas free from contact with flammable chemicals.
 5. Prohibit smoking when loading and unloading flammable chemicals.
 6. Do not store flammable chemicals where sparks from overhead electrical equipment can start a fire.
 7. Use explosionproof wiring and electrical equipment where flammable chemicals are stored or handled.
 8. Provide adequate shower facilities for all personnel handling chemicals.
 9. Give all personnel handling fluorides detailed safety instructions.
- Fluorides.
1. Avoid breathing fluoride dust; wash thoroughly after handling fluorides and clean up all spillage.
 2. Respirators, chemical goggles, rubber gloves, and protective clothing must be worn by all personnel likely to be exposed to sodium fluoride or sodium silicofluoride dust. Rubber gloves and boots and acidproof aprons are necessary where acids, such as hydrofluoric, fluosilicic, and hydrofluosilicic, are handled. Wash protective equipment thoroughly before and after using.
 3. Take care to prevent dust or acids from entering open cuts, sores, or lesions.
 4. Provide all fluoride-handling equipment, such as storage bunkers, weight hoppers, and dry-feed machines, with devices to keep the dust hazard down. Acid pumps will be provided with a clear plastic shield around glands and parts to protect personnel from acid spray.
 5. Store fluorides in a specific, well-identified area. Storage in various or changing locations may result in a mistake in identifying the chemical. All acid containers will be covered, well vented, and stored where there is no fire hazard.
 6. Containers that have held fluoride compounds will be disposed of in a safe manner by personnel protected as described above.

HOUSEKEEPING

Promote good housekeeping at the water treatment plant. Some good housekeeping rules to adhere to are as follows:

- Tools should be returned to their proper place when no longer needed.
- Empty bottles or other such objects should not be left around on the floor where someone is likely to trip or fall over them.
- See that the plant is kept neat and clean at all times.
- Among other things, ensure that passageways are kept free of grease and oil.
- Switchboards must not be used as clothes racks. Do not work around electrical apparatus or wiring with wet hands or in wet shoes or clothes.
- Workers on night watch or otherwise required to perform duties alone around water treatment plants should be capable of swimming at least 100 feet while dressed in the usual type of work clothing.
- An employee performing duties inside the tank guardrail should wear a safety belt and lifeline attached to the guardrail.
- Guardrails should be maintained around all water treatment plant open tanks. Handholds or suitable ladders should be maintained on one side wall of each open tank. Suitable handrails 8 to 12 inches above the waterline should be maintained on each side of open tanks.

Q24. To reduce chlorine hazards, what maximum amount of chlorine should you store in the chlorinator room?

Q25. What do you use to test for leaks on chlorine cylinders, equipment and systems?

Q26. If someone is affected or overcome by chlorine or its action, what is the first thing you should do?

RESPIRATORY PROTECTIVE APPARATUS

LEARNING OBJECTIVE: Recognize and understand procedures for operation, donning, use, and maintenance of different types of personal respiratory protective gear.

In water treatment and sewage maintenance work, you may use various types of respiratory protective apparatus, such as self-generating oxygen-breathing apparatus (OBA) and self-contained oxygen-breathing apparatus. Personnel directed to use this equipment should practice regularly with it to become proficient in putting it on quickly and to become accustomed to breathing through it.

SELF-GENERATING OXYGEN-BREATHING APPARATUS

Self-generating oxygen-breathing apparatus (OBA) gives respiratory protection in moderately and extremely high concentration of toxic gases or vapors or in an atmosphere deficient in oxygen. This equipment includes the following parts: a canister that holds chemicals to absorb carbon dioxide and moisture from the exhaled air and generates oxygen, and a breathing bag that serves as an air reservoir and a cooling chamber for inhaled air. Inhalation and exhalation check valves are parts of this equipment. Figure 8-7 shows a self-generating A-4 oxygen-breathing apparatus.

NOTE

Do not use the OBA in an explosive area as it is a fire hazard.

You must become thoroughly acquainted with oxygen-breathing equipment before wearing it in service. More information on the A-4 oxygen breathing apparatus can be found in the *Basic Military Requirements*, NAVEDTRA 12043.

SELF-CONTAINED OXYGEN-BREATHING APPARATUS

The self-contained oxygen-breathing apparatus (figs. 8-8 and 8-9) is effective for limited use against any poisonous gas or oxygen-deficient atmosphere, such as when you are inspecting long, large sewers where a hose mask would be impractical. This equipment generally includes the following parts: a steel cylinder or bottle containing oxygen as needed at slightly higher than normal pressure.

The respiratory apparatus should be kept in accessible locations, but in quarters segregated from probable gas hazards.

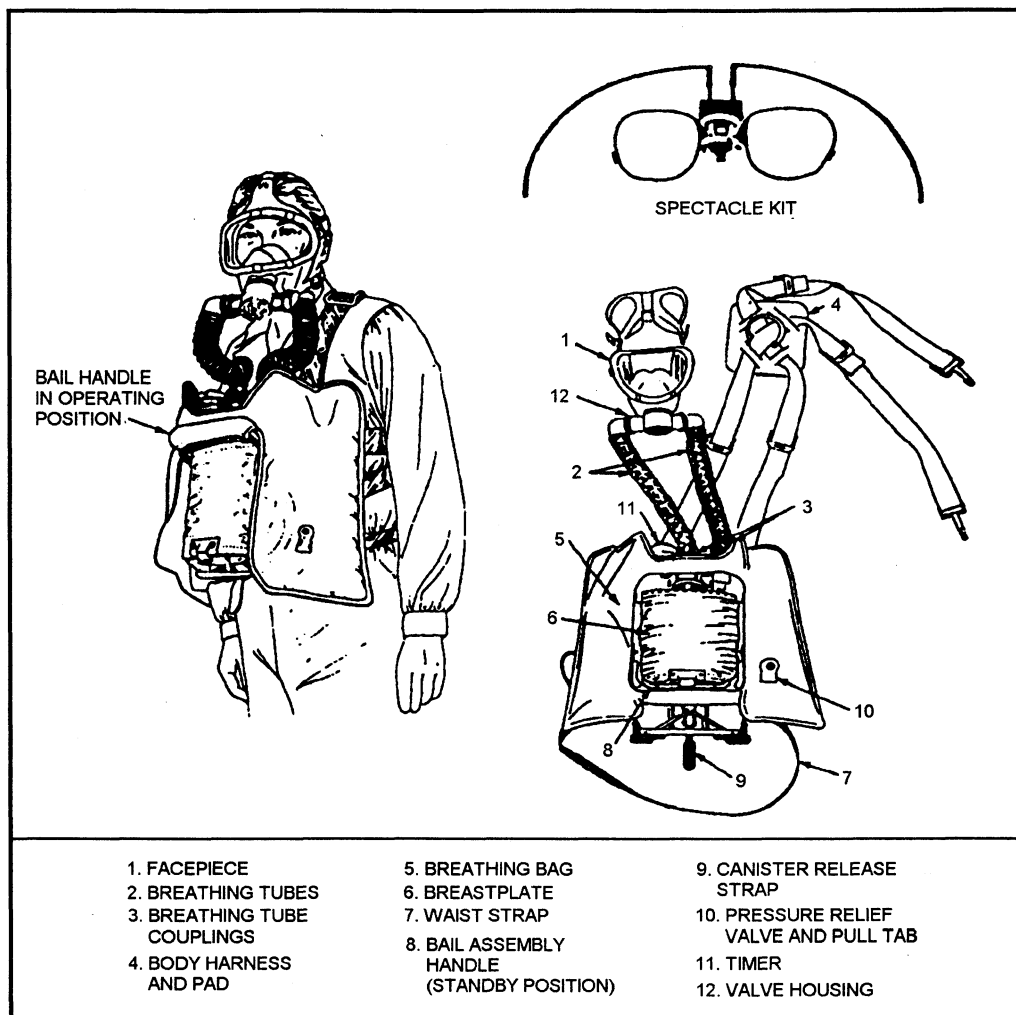


Figure 8-7.—Self-generating A-4 oxygen-breathing apparatus.

Self-Contained Demand Regulator Equipment

The demand regulator type of self-contained breathing equipment provides face and respiratory protection for the user but is limited to the amount of air or oxygen carried in the supply cylinder. This equipment consists of a full face mask, corrugated flexible breathing tube, demand regulator, air or oxygen supply cylinder, and harness.

A regulator pressure gauge should be in view of the user at all times. This gauge shows the cylinder pressure and reserve supply. During normal operation, the emergency bypass valve should be fully closed (turn clockwise for closing), and the regulator control valve to the main line should be fully opened (turn counterclockwise for opening) and locked in position by the locking device. This valve shuts off the automatic demand regulator if it fails or is damaged. It should be closed only after the emergency bypass has

been opened. ONCE THE VALVES ARE SET IN THIS POSITION, THEY SHOULD NOT BE CHANGED UNLESS THE EMERGENCY BYPASS VALVE IS NEEDED. The air or oxygen supply is controlled by a main valve on the cylinder. (Open and close these valves with your fingers; do not use force.)

The operations described are intended for one brand of demand regulator equipment. Operations for other types of brands are similar, but the location of some of their parts may be different. This manual suggests these operations as a guide for all demand regulator equipment.

Donning the Facepiece (six-strap model)

Since facepieces for most breathing apparatus are applied in a similar manner, a step-by-step method of applying a six-strap model will be described only once and will be referred to throughout this manual. Head



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Figure 8-8.—Self-contained oxygen-breathing apparatus with bottle.

harness straps should be snug, not too tight. Although other types of facepieces may have fewer head harness straps or may have various sizes and shapes of lenses, most facepieces are similar in design. Because of this close similarity, the methods of application can be adapted to the one described and shown by figures 8-9, 8-10, and 8-11.

The six steps for donning the facepiece are as follows:

1. Loosen the head harness strap so that the tab end of each strap is against the facepiece buckle.

With both hands, fold these straps in a bundle across the top of the facepiece. Hold the facepiece and straps by grasping the upper sides with both hands (fig. 8-10).

2. Place the chin well into the small pocket at the bottom of the facepiece and fit the facepiece to the temples and forehead.
3. Release the facepiece with both hands, but hold secure to the harness and pull the harness over the top of the head.
4. Tighten the chin straps first by pulling out and back on the tabs provided. This operation secures the facepiece in position and places the head harness on the back of the head so that the bottom strap is across the back of the neck and below the ears.
5. Tighten the temple straps next and secure the facepiece snugly to the head.
6. Tighten the top straps last, as shown in figure 8-10.

Notice that the head harness is placed at the back of the head, not on top. If the top straps are tightened first, the head harness may be pulled out of position. The facepiece is now ready to be tested for leakage. Hold one hand over the end of the breathing tube, or squeeze the breathing tube, and then try to inhale. If the facepiece fits snugly, it should collapse against the face.

Donning the Side Shoulder Strap Model

The harness of the side shoulder strap model must be prepared before the equipment is lifted from the floor. The only place necessary to grasp the harness or equipment is where the takeup strap and shoulder strap are buckled together. The takeup strap should be arranged without twist, although the wide shoulder strap may appear to have a half twist. This twist is normal for proper fitting to the back and shoulder. The steps for donning the side shoulder strap model (fig. 8-10) are as follows:

1. Fold the loop end of the harness takeup strap over upon itself and grasp the takeup strap with the right hand, at this point, with the palm down.
2. Lift the equipment up along the left side of the body by raising the right hand and arm toward the head. At the same time, run the left arm through the loop formed by the harness and



STEP 1.



STEP 2.



STEP 3.



STEP 4.



STEP 5.



STEP 6.

54.503

Figure 8-9.—Donning the facepiece (six-strap model).

cylinder, and grasp the cylinder control valve with the left hand. This action allows the left hand to open the cylinder control valve and to help boost the cylinder toward the back.

3. Continue the swinging movement; bring the right hand and arm over the head and place the wide shoulder strap on the right shoulder. Boost the cylinder into position on the back as shown.
4. Release the main line of the shoulder takeup strap from the right hand but hold firmly to the loop end. Pull down and out on the loop end to tighten the harness to fit the body.
5. Fully open the cylinder control valve before it has been released by the left hand.
6. Reach behind the body with the right hand and secure the waist strap hanging from the lower

part of the cylinder. Bring this waist strap around the waist from the right side and snap it into the ring just below the demand regulator valve.

7. With the right hand, pull to the right and out on the loop end of the waist strap to tighten. The equipment is now in the standby position, and the facepiece may be applied to the head any time before entering the contaminated area.
8. Donning the facepiece is the same as has been described (fig. 8-9). The facepiece will not yet have been connected to the equipment.
9. The breathing tube can be connected to the demand regulator any time the wearer desires, usually just before entering the contaminated area to conserve the cylinder supply. As long as



Figure 8-10.—Donning the side shoulder strap model of the self-contained oxygen-breathing apparatus.

the breathing tube is not connected, the wearer is breathing air from the atmosphere.

10. The minute the connection has been made to the demand regulator, the wearer breathes entirely from the cylinder.

Donning the Back Strap Model (overhead method)

Before starting the donning procedures for the back strap model (fig. 8-11) and as described below, open the air or oxygen supply cylinder valve two full

turns or more, and check the pressure gauge on the regulator to see that it is operating properly. Then proceed as follows:

Step 1: Grasp the backplate in a convenient manner with one hand on each side of the plate in preparation to lift the equipment from the case.

Step 2: Lift the equipment from the case and permit the demand regulator and harness to hang freely.

Step 3: Raise the cylinder overhead and permit the elbows to find their respective harness shoulder strap loops.



STEP 1.



STEP 2.



STEP 3.



STEP 4.



STEP 5.



STEP 7.



STEP 9.

Figure 8-11—Donning the back strap model of the self-contained breathing apparatus.

54.505

Step 4: Continue to carry the cylinder overhead toward the back where it can be released to the back.

Step 5: Lean forward when the cylinder is released so that the cylinder will not slide down the back. Fasten and adjust the upper chest strap to hold the demand regulator in position. If equipment is

donned with the chest strap fastened, adjustment is enough.

Step 6: With both hands on their respective sides, grasp the two harness takeup straps located near the chest, just below the armpits, and pull down and out to tighten the equipment firmly to the back.

Step 7: Fasten and adjust the lower waist strap which will conclude harness adjustment to secure the equipment to the body.

Step 8: Donning the facepiece is the same as has been previously described.

Step 9: The breathing tube can be connected to the demand regulator any time the wearer desires.

Daily Inspections

Self-contained, demand-type breathing apparatus must be kept perfect to protect it as designed.

The first step to ensure that breathing apparatus is safe for immediate use is daily inspection. The breathing apparatus must be inspected daily by the fire fighter who will be using the equipment. Items that must be daily are as follows:

1. Cylinder air pressure should be no less than 1,850 psi or normal pressure recommended by the manufacturer.
2. The regulator and low-air alarm bell must be tested by opening the tank valve to charge the high-pressure lines and regulator; then, close the tank valve and breathe pressure off the regulator to assure proper operation of “main line valve” and “low-air alarm bell.”
3. Check all body harness straps. The harness should be tangle-free and all straps extended to their limit.
4. The facepiece should be checked for cracks, tears, and broken head straps. All head straps should be extended to their limit.

The next two steps, to ensure proper operation of breathing apparatus, are performed immediately after the apparatus has been used. These steps are cleaning and sanitizing and recharging air cylinders.

A poorly maintained breathing apparatus is not only unsafe to use, but in most cases, very unpleasant. Dirty moving parts may not work. A facepiece that has not been cleaned and sanitized is not only unpleasant to wear but can spread cold and influenza germs throughout a department. An air cylinder with less air than prescribed by the manufacturer renders the apparatus inefficient or useless.

The facepiece should be thoroughly washed with warm water, any mild commercial disinfectant, and then rinsed with clear, warm water. Special care should be given to the exhalation valve to ensure proper

operation. The air hose should be inspected for cracks or tears. Then the facepiece should be dried with a lint-free cloth. The entire apparatus, including the storage box, should then be wiped down with a sponge, using the same disinfectant solution.

Periodic Inspection and Care

After each 3-month period, remove the equipment from service and check valves, pressure regulators, gauges, harness, and facepiece. The following functional test and inspection should then be made: check the facepiece, hose, and exhalation valve by inhaling slowly with the thumb over the end of the hose connection. Make the hose connection and check the performance of the regulator. Inhale deeply and quickly. The regulator should supply a full flow to give the user all the oxygen demanded. If, on slow inhalation, a “honking” sound is heard in the regulator, it can usually be stopped by inhaling faster. The sound is caused by the bellows vibrating and in no way affects the performance or safety of the regulator. If the bellows vibrate continuously or excessively, competent technicians recommended by the manufacturer should overhaul the regulator. If the demand valve sticks open slightly (this may be caused by a cold diaphragm), the breathing gas will continue to flow when the wearer is not inhaling. This condition can usually be corrected by “blowing back” on the regulator. Operate the regulator several minutes to exercise the diaphragm and valves before condemning the regulator. With the hose out of the connection, close off the cylinder valve. With 1,980 psi indicated on the regulator gauge, the regulator and the regulator hose assembly should hold the trapped-in pressure.

After 2 1/2 years, the regulator and regulator hose should be returned to the factory or to its representative for test and/or repair. After each 5-year period, these cylinders should be hydrostatically tested. Each cylinder is stamped with the month and the year of manufacture and the date of the last test to meet requirements of the United States Department of Transportation (formerly Interstate Commerce Commission). Always empty cylinders before returning them for service and test.

Testing Cylinder Valve for Leaks

Use a soap solution to inspect the place where the cylinder pressure gauge connects to the valve body and the safety plugs. With the regulator hose and regulator attached to the cylinder valve, open the cylinder valve.

When bubbles appear around the valve stem and packing gland nut when a soap solution test is being made, the packing nut should be tightened or the gland packings should be replaced.

With the regulator hose disconnected, close the cylinder valve. When bubbles form at the regulator hose connection when a soap solution is applied, the valve seat is leaking. Open and close the valve quickly several times and allow pressure to blow through quickly. This procedure may clear the valve seat of dirt and correct the trouble. If the leak continues, the cylinder should be returned to the factory for test and repair.

Q27. A self-generating oxygen-breathing apparatus protects you from what type of atmospheres?

Q28. What is the last step in donning a facepiece?

Q29. Oxygen cylinders are hydrostatically tested how often?

WATER STORAGE FACILITIES

LEARNING OBJECTIVE: *Identify different types of water storage facilities and their associated support equipment. Understand their operation, uses, and maintenance.*

The operation of storage facilities in the distribution system is largely a matter of maintaining sufficient levels through adequate pumping and controlling water flow through appropriate valves.

Live storage, where water is constantly circulating from the supply into the distribution system, is preferred to noncirculating storage because the latter depletes the chlorine in the water and allows tastes and odors to develop. If dead storage is necessary, the operator must maintain a close watch on chlorine residuals and the development of odors and tastes, and report conditions regularly to higher authority.

TYPES OF STORAGE

Facilities for storage of water include open reservoirs, underground reservoirs, and elevated storage tanks. Ground storage reservoirs may be the same or similar to those shown in figure 8-12. Three types of elevated storage tanks, which you may find at naval activities, are pictured in figure 8-13. You may also see standpipes, like the one shown in figure 8-14, used at some activities. Standpipes are, in effect, ground level storage tanks. The distinguishing

characteristic of a standpipe is its relatively small diameter and extra height to provide head pressure. Under no conditions should the amount of stored water be reduced to a point below that necessary for fire fighting. Daily records maintained by the operator help ensure against such a condition.

Pneumatic water tanks are usually found in use at smaller installations. They consist of a pressure vessel partly filled with water, and a compressor unit that supplies air pressure to produce the desired water pressure. Pneumatic tanks may be within buildings, on outside surface locations, or underground. While the operation of these units is usually automatic, the operator is responsible for the effective operating of pressure equipment. The manufacturer's instructions should be consulted for methods of starting, stopping, and operating this pressure equipment.

MAINTENANCE OF STORAGE FACILITIES

Here are the elements in the maintenance of storage facilities: the construction materials- concrete or steel; and the location of the tank-ground level, belowground, or elevated.

Foundations

All tanks have foundations of concrete, wood, or steel. Each material has its own maintenance procedures.

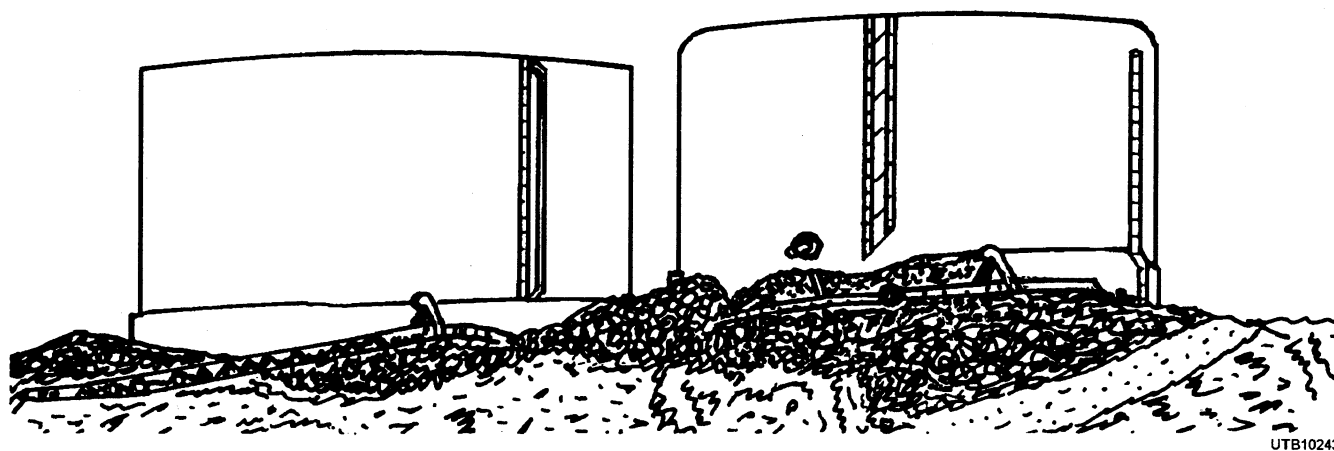
Concrete foundations should be inspected semiannually for settlement, cracks, spalling, and exposed reinforcing. When deterioration has set in, the foundation should be repaired with a mixture of 1 part cement to 1 part sand.

Wood foundations and pads should be inspected for split members, rot, termite infestation, and for direct soil contact of untreated wood. Any repairs necessary to remove the undesirable condition should be made.

Maintenance procedures for steel foundations are similar to those given later in this chapter for elevated storage tanks.

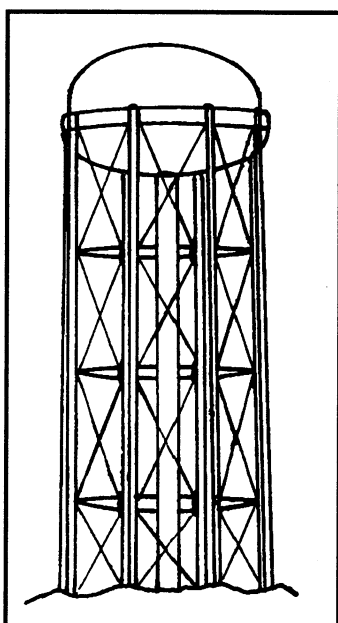
Concrete Storage Tanks

Concrete storage tanks may be either prestressed or nonstressed design. There is little difference in the maintenance procedures, which depend mainly on the location of the tank-aboveground or belowground.



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Figure 8-12.—Ground storage reservoir.



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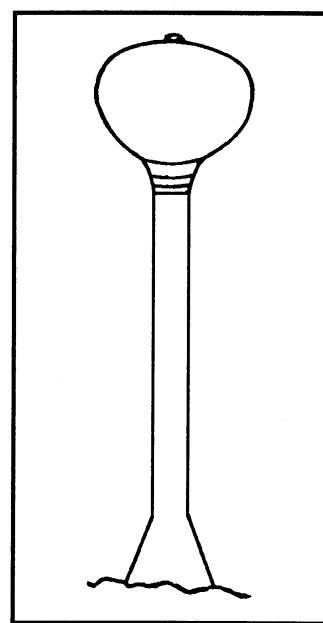
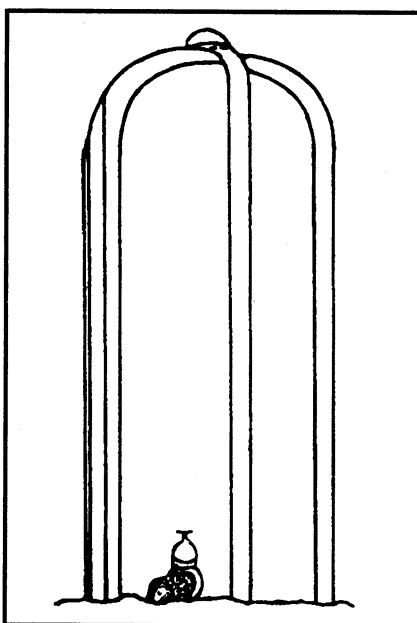


Figure 8-13.—Three types of elevated storage tanks.

GROUND LEVEL STORAGE.—During early spring, ground level storage facilities should be inspected for watertightness and structural conditions and repairs made as necessary; at other intervals, the maintenance procedures set forth in the following paragraphs should be performed.

Semiannually, exterior walls should be marked where leakage or seepage occurs. Every spring, they should be inspected for seepage or leakage from cracks-breaks or cracks in the interior seal membrane. Dewater the tank and check both the interior and exterior surfaces for spalling caused by frost action, as well as settlement, cracks, and exposed reinforcing.

All loose, scaly, or crumbly concrete should be removed and the wall patched with rich cement grout after wetting and painting with portland cement slurry. Hardened grout should be painted with iron waterproofing compound or a similar preparation.

Cracks of 1/4-inch width and 1-inch depth should be chipped out. The cleaned crack should be moistened and painted with a cement slurry. The crack should be filled with a rich cement grout, dry enough to stay in place in the crack, but not dry enough to allow it to slough off. When the grout has hardened, it should be painted with iron waterproofing compound, or a similar preparation.

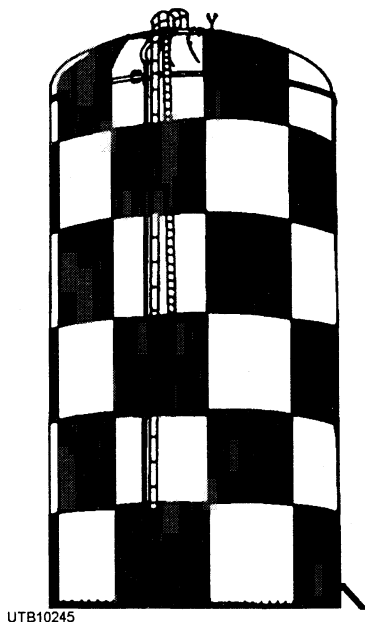


Figure 8-14.—Standpipe.

When cracks appear in prestressed concrete tanks, the problem should be referred to the erecting company for recommendations, even if the guarantee has expired or does not cover maintenance.

Every 6 months, joints should be checked for leakage at the juncture of the floor and the walls, and for loose or missing filler, debris, or trash. They should be cleaned and repaired as necessary.

Every 6 months, the roof should be inspected for the condition of the covering. Are roof hatches and other covers locked? Are the screens on the overflow or at other locations in place? They should be cleaned as necessary.

Where the tank rests on an earth embankment, it should be checked for erosion from the lack of full sod or vegetation coverage, and for damage from burrowing animals, improper drainage, ponding water along the base, or leakage through the embankment or along the outlet piping. When leakage exists through the embankment, the tank should be drained and the bottom inspected for failure or cracks.

UNDERGROUND STORAGE.—If storage tanks are constructed belowground or are surrounded by an earth embankment, the semiannual inspection and repair comprise only the interior walls, roofs, accessories, and embankment. The inspection procedures and maintenance operations are the same as described above for ground level storage facilities. When the earth embankment, surrounding soil, or interior of the tank shows evidence of tank leakage, the earth may need to be excavated and repairs made on the walls.

ELEVATED STORAGE.—Concrete storage tanks elevated aboveground require the same inspection and repairs as outlined above, where applicable.

Steel Storage Tanks

Usually, outside contractors maintain and repair steel tanks. At times, though, you may have to perform various inspection and maintenance duties, such as those discussed in the following section.

GROUND LEVEL STORAGE.—Annually, after the winter season, steel storage tanks should be inspected for ice damage, watertightness, and structural conditions. Twice each year, the maintenance procedures set forth in the following paragraphs should be followed.

Tanks walls (exterior and interior) and bottom (interior) should be inspected semiannually for rust corrosion, loose scale, leaky seams and rivets, and for the condition of the paint (both inside and out). Maintenance procedures to adhere to are as follows:

1. Replace rivets, or patch-leaking areas, and follow by cleaning and painting.
2. Check painted surfaces for rust, corrosion, cracking, peeling, alligatoring, caulking, fading, or complete loss of paint. Empty the tank and examine the interior paint, as corrosion is more likely on the inside. When the interior needs painting, arrange to take the tank out of service. Paint the tank interior as often as the exterior (more often if the stored water is corrosive); unless the tank is equipped with cathodic protection.
- Make certain that the paint used will protect the metal against corrosion. Consult the applicable guide specifications for paint selection and application.
- Use only new coat if the previously applied coat is in fair condition. Bare spots of steel should be painted with a spot or patch coat before the finish coat is applied. When the condition of the old paint is bad, use a complete primer coat.

Every 6 months, the roof and its appurtenances—screens on overflows, hatches, and manholes, as well as the condition of the paint, should be inspected. Maintenance procedures to adhere to are as follows:

1. Make certain that hatch covers and manholes are in place and locked and that screens are in place to prevent the entrance of birds, insects, and animals.

2. If the spider rods under the roof have corroded, remove them, as they are needed only during erection.
3. Paint the roof, selecting the proper paint for the particular location.

As pointed out earlier, standpipes are, in effect, ground level storage tanks. Inspection and maintenance procedures for standpipes are the same as those for ground level steel storage tanks.

UNDERGROUND STORAGE.—When steel storage tanks are constructed belowground or are surrounded by an earth embankment, the semiannual inspection and repair include only the interior of the tank, the roof, and the accessories. The inspection and maintenance procedures are the same as given for ground storage steel tanks.

ELEVATED STORAGE.—Besides the inspection and maintenance procedures set forth above for ground storage steel tanks, the following specific procedures apply to elevated storage steel tanks.

Semiannually, tower structures should be checked for rust and corrosion, loose, missing, bowed, bent, or broken members; loose sway bracing; misalignment of tower legs; and evidence of unstableness. Items that must be covered are as follows:

1. Inspect the back surface of the lattice bars and anchor bolts, the inside of boxed channel columns, and pockets where batten-plate connections and column bases form pockets for collecting trash and water. Clean and paint these enclosures, and fill with concrete as necessary to shed water.
2. Check the bases and the baseplates for evidence that water has collected at that point; if water is found, drill a 1 1/2-inch hole through the channel-boxed section to allow complete drainage. Then grout the baseplate with a mixture of sand and asphalt to prevent water from running under the plates. Taper the grout from the top edge of the plate to the pier.
3. Check the sway bracing and tighten the turnbuckles if necessary. Examine under clevis pins and rod loops where corrosion may be greatest. Drill holes in the balcony floor to eliminate standing water.

Besides general roof inspection and repair, as described for ground storage steel tanks, obstruction and navigation lights should be inspected and

relamped if necessary. Additional items that should be covered are as follows:

1. Check the operation of all other lights; check hoods, shields, and receptacle fittings; look for missing or damaged parts. Repair or replace parts as necessary.
2. Check lightning rods, terminals, cables, and ground connections.

In cold climates, potable water storage tanks (with small riser pipes) and elevated storage tanks (for fire protection only) usually have heating equipment to prevent freezing in severe low temperatures. Checks that must be conducted are as follows:

1. Annually, 2 months before the freezing season, inspect the riser for deterioration of the frost covering. Seal any openings to reduce heat loss. Also, check the heating system to ensure proper operation during the next cold season.
2. Annually, 1 month before the freezing season, operate the heating system for 8 hours to check all elements under operation.

CATHODIC PROTECTION EQUIPMENT.—Only impressed current cathodic protection systems are used for protecting steel water storage tanks against corrosion. This system of protection may be applied to all types of steel water tanks—ground level standpipe, underground, and elevated. Refer to the material presented earlier in this chapter for a discussion of inspection and maintenance procedures for impressed current systems. Also, other applicable procedures are as follows:

- Annually, note and record the current flow during the operation. If the current does not flow, check the fuses, electrodes, which contact the tank, ground wire connection to the tank, and the immersion of electrodes. If the equipment is operating at voltages or amperages above those listed on the nameplate, the rectifier may be damaged.

CAUTION

Make certain that the connections to the rectifier are not reversed. Reversed connections will result in tank damage.

Annually, check the operating record to determine if the electrodes are immersed at all times, or almost all the time. If the electrodes are not immersed, there will be no damage to the

unit; however, protection is not provided when the electrodes are not immersed.

- Annually, check the anode condition and replace the anodes as necessary. Also, check the current flow; if it has diminished since the previous inspection, the anode probably needs to be renewed.
- Annually, in freezing climates, protect electrodes from ice, which may tear them from their hangings or damage them. If ice formation is severe, turn off the current, remove the electrodes, store them until the freezing season is past, and then reinstall them.
- Annually, test the effectiveness of the cathodic protection system in one of two ways.
 1. Scrape and polish a spot on the tank wall at a point always immersed. At quarterly intervals, lower the water and inspect the spot; if protection is adequate, the spot will remain uncorroded.
 2. Suspend two polished mild steel test plates in the tank at an elevation where they will always be immersed (use No. 6 galvanized steel wire). Ground one plate to the tank wall, but have the other plate insulated from the tank. The extent of corrosion on the grounded plate will come close to the corrosion of the protected tank; the extent of corrosion on the other plate is a measure of the corrosion that would occur if the tank were not protected.

Pneumatic Tanks

As pneumatic tanks are usually on smaller installations, they may be too small for interior inspection, except for observations through a removable hand plate. The size, therefore, shows the inspection procedures to be followed. Standard inspection procedures are as follows:

Quarterly, inspect the air pump and motor to make certain both are operating properly. Check the operating record to determine the time cycle of air pump operation. If the records show a decreasing time cycle, check for possible air line leaks.

Quarterly, check valve operations; particularly, check the pressure-relief valve. Repair or replace as necessary.

Annually, check the tank for signs of corrosion, both internally and externally. If corrosion products are apparent, take the following action:

1. If the tank is large enough to permit the entry of personnel, paint the inside with corrosion-resistant paint, or line it with cement. If the tank is too small to permit entry, consider changes in operation or in chemical treatment to reduce corrosiveness of water. Corrosion is most likely in areas alternately exposed to air and water.
2. Paint the exterior as needed.

Appurtenances

Every 6 months, ladders, walkways, guardrails, handrails, stairways, and risers should be inspected for rust, corrosion, poor anchorage, loose or missing pieces, or other deterioration or damage. Standard inspection procedures include the following:

1. Be sure to check ladders inside as well as outside the tank. Replace worn, corroded, or missing parts; check for deteriorated lugs and rungs as necessary; and, make other repairs to ensure safety for the operators. Check revolving ladders on the roof for the condition of connection at the final hookups.
2. Ensure that bolts, screws, rivets, and other connections are tight.
3. Inspect the condition of the altitude valve vault and the valves for proper operation. Repair, clean, and paint all equipment when necessary.
4. Check the water level indicator for improper operation and repair when necessary.
5. Inspect the cathodic protection equipment and repair when necessary (follow instructions given in previous portions of this chapter).
6. At semiannual intervals, check the electrical connections to lights, cathodic protection, and so forth, for breaks in the conduit. Remove the conduit inspection plates and examine the internal connections for tightness and adequacy; also check relays for weak springs, worn or pitted contacts, and defective operation. Repair and eliminate all undesirable conditions.

Grounds

At semiannual intervals, remove all accumulations of dirt, trash, debris, and excess foliage in the area surrounding the storage tank.

Maintenance Procedure Schedule

The maintenance operation frequency and schedule of inspections for storage facilities are shown in appendix III, table H.

Q30. What are the three types of water storage?

Q31. Water storage tanks are made of what two materials?

Q32. Rich cement grout should be used during interior wall repairs of a ground level concrete storage tank after application of what type of tank preparation?

Q33. What type of cathodic protection is used to protect elevated steel water tanks from corrosion?